Clinopyroxene Group
\( \text{ABSi}_2\text{O}_6 \)

Presented by
Joyleen Desai
Paul Sandlin

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Diopside  Hedenbergite

Jadeite  Acmite  Spodumene

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Chemical Composition
\( \text{ABSi}_2\text{O}_6 \)

<table>
<thead>
<tr>
<th>Mineral</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diopside</td>
<td>( \text{Ca}^{2+} )</td>
<td>( \text{Mg}^{2+} )</td>
</tr>
<tr>
<td>Hedenbergite</td>
<td>( \text{Ca}^{2+} )</td>
<td>( \text{Fe}^{2+} )</td>
</tr>
<tr>
<td>Jadeite</td>
<td>( \text{Na}^+ )</td>
<td>( \text{Al}^{3+} )</td>
</tr>
<tr>
<td>Acmite</td>
<td>( \text{Na}^+ )</td>
<td>( \text{Fe}^{3+} )</td>
</tr>
<tr>
<td>Spodumene</td>
<td>( \text{Li}^+ )</td>
<td>( \text{Al}^{3+} )</td>
</tr>
</tbody>
</table>
Structural Cell Parameters
Monoclinic
Space Group: \( C2/c \)
Point Group: \( 2/m \)

<table>
<thead>
<tr>
<th>Mineral</th>
<th>( a )</th>
<th>( b )</th>
<th>( c )</th>
<th>( \beta ) (calc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diopside</td>
<td>9.761</td>
<td>8.926</td>
<td>5.258</td>
<td>3.26</td>
</tr>
<tr>
<td>Hedenbergite</td>
<td>9.827</td>
<td>8.994</td>
<td>5.261</td>
<td>3.68</td>
</tr>
<tr>
<td>Jadeite</td>
<td>9.418</td>
<td>8.562</td>
<td>5.219</td>
<td>3.37</td>
</tr>
<tr>
<td>Acmite</td>
<td>9.65</td>
<td>8.79</td>
<td>5.29</td>
<td>3.59</td>
</tr>
<tr>
<td>Spodumene</td>
<td>9.52</td>
<td>8.32</td>
<td>5.25</td>
<td>3.17</td>
</tr>
</tbody>
</table>

Source: http://webmineral.com

Structure

Thermal Expansion

<table>
<thead>
<tr>
<th>Mineral</th>
<th>( T ) Range (°C)</th>
<th>( a \times 10^4 ) °C(^{-1} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diopside</td>
<td>24-1000</td>
<td>3.97</td>
</tr>
<tr>
<td>Hedenbergite</td>
<td>24-1000</td>
<td>3.45</td>
</tr>
<tr>
<td>Jadeite</td>
<td>24-800</td>
<td>3.09</td>
</tr>
<tr>
<td>Acmite</td>
<td>24-800</td>
<td>2.78</td>
</tr>
<tr>
<td>Spodumene</td>
<td>24-760</td>
<td>2.83</td>
</tr>
</tbody>
</table>

Source: Cameron et al. (1973)
Compression

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Bulk Modulus (GPa)</th>
<th>Shear Modulus (GPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diopside</td>
<td>118.0</td>
<td>68.0</td>
</tr>
<tr>
<td>Hedenbergite</td>
<td>119.0</td>
<td>63.9</td>
</tr>
<tr>
<td>Jadeite</td>
<td>129.3</td>
<td>79.11</td>
</tr>
</tbody>
</table>

Source: http://www.ciw.edu/schutt/depletion/depletion_intro.html

Occurrences

- Clinopyroxenes are found in mafic and ultramafic igneous rocks
- They are also found in medium- to high-grade metamorphosed mafic rocks

Metamorphic Facies

Source: Spear (1995)
Geothermobarometry

- Inferring T and P
  - Thermodynamic modeling and calculations, electron microprobe
- Assume equilibrium for sub-assemblages
- Possible to infer PT conditions at various stages in rock history
  - Can’t find ages, but can construct PT time path

Garnet-Cpx Thermobarometer

Source: Spear (1995)

Diopside-Enstatite Geothermometer

- Below the solvus, a pyroxene of composition X will unmix to produce two pyroxenes
- The degree of unmixing is a function of temperature

Source: Perkins (1998)
Crystal Structure

Hydrous Sodic Cpx in the Upper Mantle

Source: Smyth et al. (1991)

Hydrous Importance

- Cpx in eclogites as mantle samples
- X-ray crystal structure refinement and analytical transmission electron microscopy (McCormick, 1996)
  - OH at dominant 3470 cm$^{-1}$ band
- O2 site is underbonded according to Pauling bond strength
  - M2 site is the most likely candidate for OH, 250-1840 ppm by weight
- Cpx is stable at P=12 GPa, 30-400 km
- Cpx is 5-10 times more abundant in mantle rocks